



Una foto sullo stato dell'esperimento BESIII

Giulio Mezzadri, per la collaborazione BESIII
INFN Ferrara – Università degli studi di Ferrara
IFAE2017 – Trieste, 21/04/17



Indice degli argomenti

IHEP, BESIII e BEPCII

Nuovi stati vettoriali esotici Y

Misure di precisione alla soglia della Λ_c

Pillole dagli altri ambiti



The image shows the exterior of a large, modern building with a light-colored, textured facade. The words "Institute of High Energy Physics" are inscribed in large, raised, golden-yellow letters across the front. To the left of the text is a circular emblem featuring a stylized particle detector or accelerator component. The building has several windows and a dark roofline. The sky is a clear, pale blue.

Institute of High Energy Physics

IHEP, BEPCII e BESIII

Europe (14)

US (5)

Univ. of Hawaii
Carnegie Mellon Univ.
Univ. of Minnesota
Univ. of Rochester
Univ. of Indiana

Mongolia (1)

Institute of Physics and
Technology

India (1)

Indian Institute of Technology

Pakistan (2)

Univ. of Punjab
COMSAT CIIT

Germany: Univ. of Bochum,
Univ. of Giessen, GSI

Univ. of Johannes Gutenberg
Helmholtz Ins. In Mainz, Univ. of Munster

Russia: JINR Dubna; BINP Novosibirsk

Italy: Univ. of Torino, Frascati Lab, Ferrara Univ.

Netherland: KVI/Univ. of Groningen

Sweden: Uppsala Univ.

Turkey: Turkey Accelerator Center

Korea (1)

Seoul Nat. Univ.

Japan (1)

Tokyo Univ.

China(32)

IHEP, CCAS, UCAS, Shandong Univ.,
Univ. of Sci. and Tech. of China

Zhejiang Univ., Huangshan Coll.

Huazhong Normal Univ., Wuhan Univ.

Zhengzhou Univ., Henan Normal Univ.

Peking Univ., Tsinghua Univ.,

Zhongshan Univ., Nankai Univ., Beihang Univ.

Shanxi Univ., Sichuan Univ., Univ. of South China

Hunan Univ., Liaoning Univ., Univ. of Sci. and Tech. Liaoning

Nanjing Univ., Nanjing Normal Univ., Southeast Univ.

Guangxi Normal Univ., Guangxi Univ.

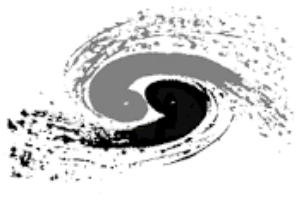
Suzhou Univ., Hangzhou Normal Univ.

Lanzhou Univ., Henan Sci. and Tech. Univ.

Jinan Univ.

~ 450 membri attivi
Da 57 istituzioni e 13 nazioni

BEPCII



Iniettore lineare

Anello di
accumulazione

collisionatore simmetrico $e^+ e^-$

$E_{cm} = 2 - 4.6 \text{ GeV}$

Luminosità istantanea: $10^{33} \text{ cm}^{-2} \text{ s}^{-1}$

BESIII è operativo dal 2009

Presi dati attesi fino al 2022-2024

BESIII

Identificatore di particelle
(TOF):

$$\sigma_t \text{ (zona centrale)} = 90 \text{ ps}$$

$$\sigma_t \text{ (zona in avanti)} = 110 \text{ ps}$$

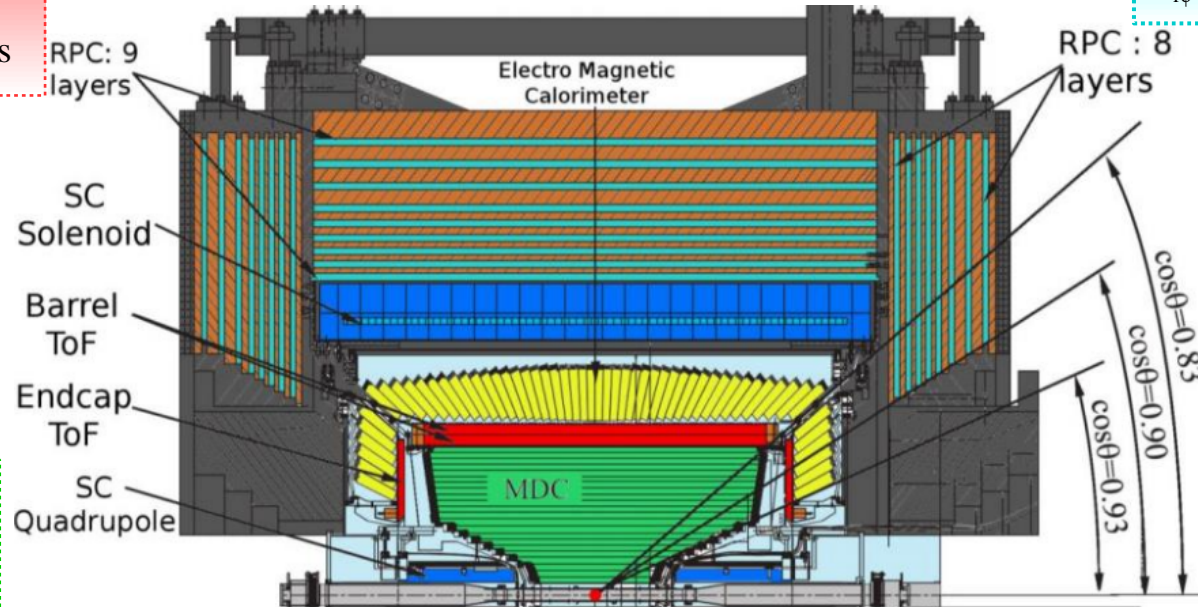
Camera a Deriva

(MDC):

$$\sigma_x \text{ (1 GeV/c)} \sim 130 \text{ } \mu\text{m}$$

$$dp/p \text{ (1 GeV/c)} = 0.5 \%$$

Campo magnetico: 1 T



Rivelatore di muoni

(RPCs):

$$\delta_{r\phi} = 1.4 \text{ cm} - 1.7 \text{ cm}$$

Calorimetro

Elettromagnetico

(ECAL):

$$dE/\sqrt{E} \text{ (1 GeV)} = 2.5 \%$$

Le prese dati di BESIII



Le prese dati di BESIII

2009: 106M $\psi(2S)$
225M J/ψ

2010: 975 pb^{-1} at $\psi(3770)$

2011: 2.9 fb^{-1} at $\psi(3770)$ (total)
482 pb^{-1} at **4.01 GeV**

2012: 0.45B $\psi(2S)$ (total)
1.3B J/ψ (total)

2013: 1092 pb^{-1} at **4.23 GeV**
826 pb^{-1} at **4.26 GeV**
540 pb^{-1} at **4.36 GeV**
 $\sim 50 \text{ pb}^{-1}$ at **3.81, 3.90, 4.09, 4.19, 4.21,**
4.22, 4.245, 4.31, 4.39, 4.42 GeV

2014: 1029 pb^{-1} at **4.42 GeV**
110 pb^{-1} at **4.47 GeV**
110 pb^{-1} at **4.53 GeV**
48 pb^{-1} at **4.575 GeV**
567 pb^{-1} at **4.6 GeV**
0.8 fb^{-1} **R-scan** from 3.85 to 4.59 GeV (104 points)

2015: **R-scan** from 2-3 GeV + **2.175 GeV** data

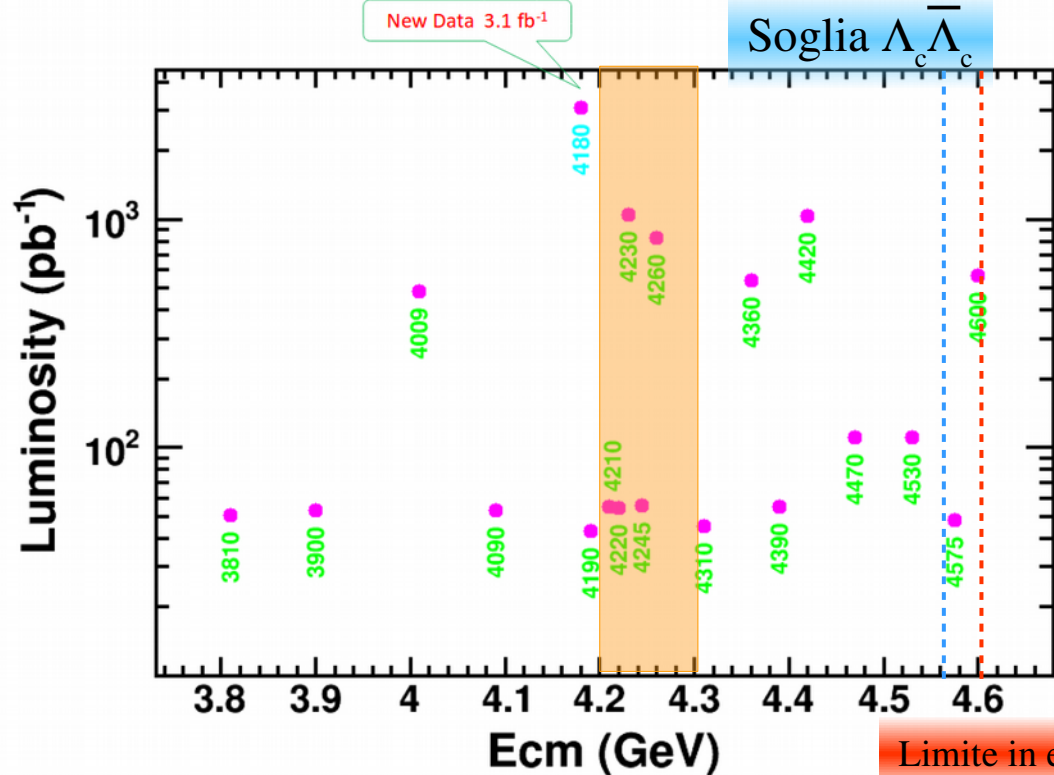
2016: $\sim 3 \text{ fb}^{-1}$ at 4.18 GeV (for D_s)

2017: $\sim 10 \times 500 \text{ pb}^{-1}$ between **4.19 and 4.30 GeV**



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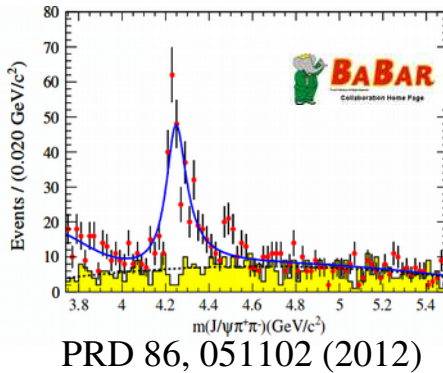
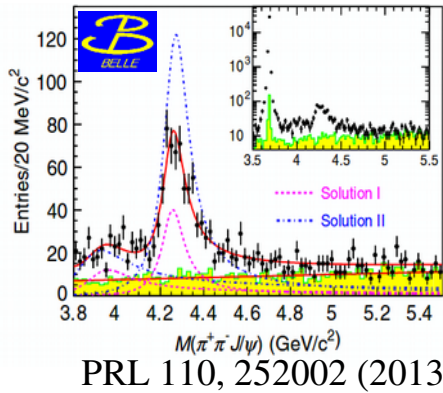


Presenza dati 2017



Nuovi stati vettoriali esotici Y

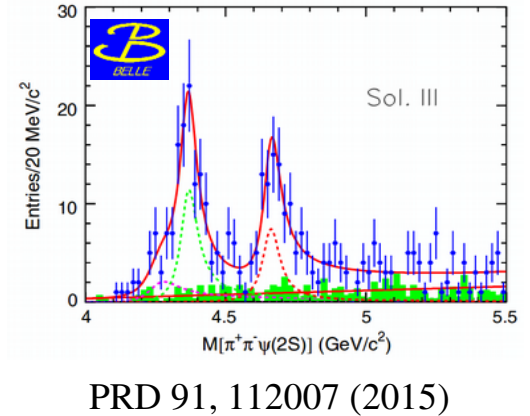
$Y(4260)$ in $e^+e^- \rightarrow \gamma_{\text{ISR}} \pi^+\pi^- J/\psi$



Stati esotici XYZ:

Stati della famiglia del charmonio
sopra la soglia DD con
caratteristiche non previste dal
modello a quark

$Y(4360)$ e $Y(4660)$ in
 $e^+e^- \rightarrow \gamma_{\text{ISR}} \pi^+\pi^-\psi'$



Nuovi stati vettoriali esotici Y

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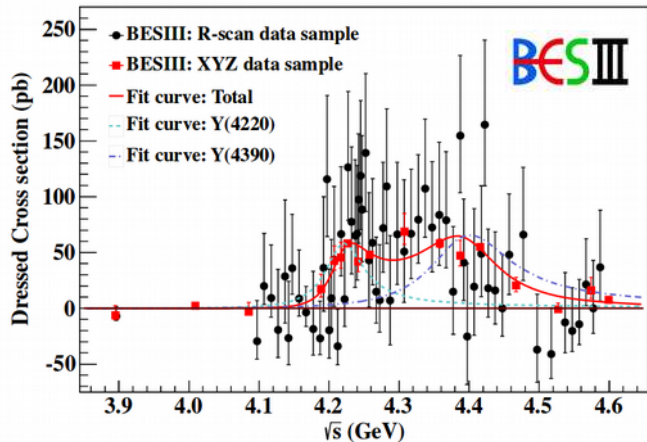
PRL 118, 092002 (2017)

“Evidence of two resonant structure in $e^+e^- \rightarrow \pi^+\pi^-h_c$ ”

Primo studio a CLEOc[1]: prima evidenza di una struttura a $4170 \text{ MeV}/c^2$ e incremento σ attorno a $4260 \text{ MeV}/c^2$

h_c ricostruita attraverso la transizione di dipolo E1

$h_c \rightarrow \gamma h_c$ e η_c in 16 stati esclusivi



[1] Phys. Rev. Lett. 96, 162003 (2006)

PRL 118, 092001 (2017)

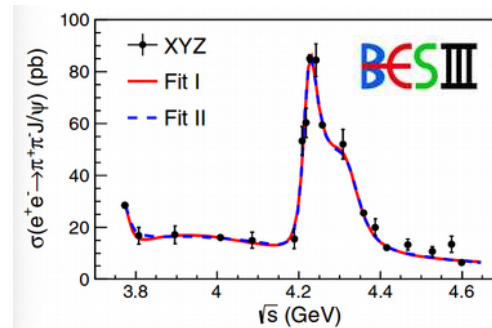
“Precise measurement of $e^+e^- \rightarrow \pi^+\pi^-J/\psi$ cross section”

Studio dell’andamento della sezione d’urto attorno alla Y(4260)

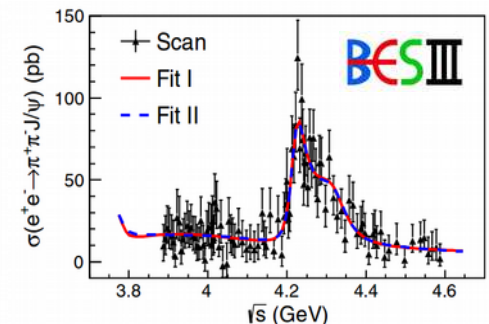
Fit simultaneo a:

XYZ data (luminosità per punto $\sim 40/\text{pb}$)

R-Scan data (luminosità per punto $\sim 7\text{-}9/\text{pb}$)



Fit I = Somma coerente di 3 BW



Fit II = 2 risonanze + esponenziale

Nuovi stati vettoriali esotici Y

PRL 118, 092002 (2017)

“Evidence of two resonant structure in $e^+e^- \rightarrow \pi^+\pi^-h_c$ ”

Y(4220):

$$M = (4218_{-4.5}^{+5.5} \pm 0.9) \text{ MeV}/c^2$$

$$\Gamma = (66.0_{-8.3}^{+12.3} \pm 0.4) \text{ MeV}$$

Y(4390):

$$M = (4391_{-6.8}^{+6.3} \pm 1.0) \text{ MeV}/c^2$$

$$\Gamma = (139.5_{-20.6}^{+16.2} \pm 0.6) \text{ MeV}$$

PRL 118, 092001 (2017)

“Precise measurement of $e^+e^- \rightarrow \pi^+\pi^-J/\psi$ cross section”

Y(4220):

$$M = (4222.0 \pm 3.1 \pm 1.4) \text{ MeV}/c^2$$

$$\Gamma = (44.1 \pm 4.3 \pm 2.0) \text{ MeV}$$

Y(4360):

$$M = (4320.0 \pm 10.4 \pm 7.0) \text{ MeV}/c^2$$

$$\Gamma = (101.4_{-19.7}^{+25.3} \pm 10.2) \text{ MeV}$$

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La Y(4360) è compatibile con quella in $\pi^+\pi^-\psi'$

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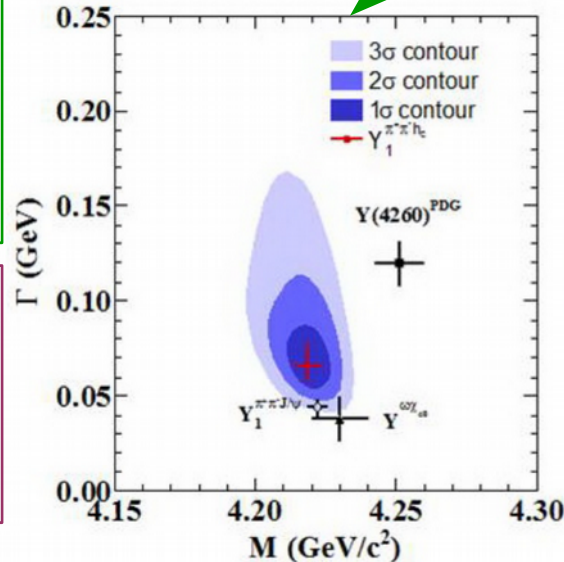
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La stessa struttura Y(4220) è osservata in $\pi^+\pi^-J/\psi$ e in $\pi^+\pi^-h_c$

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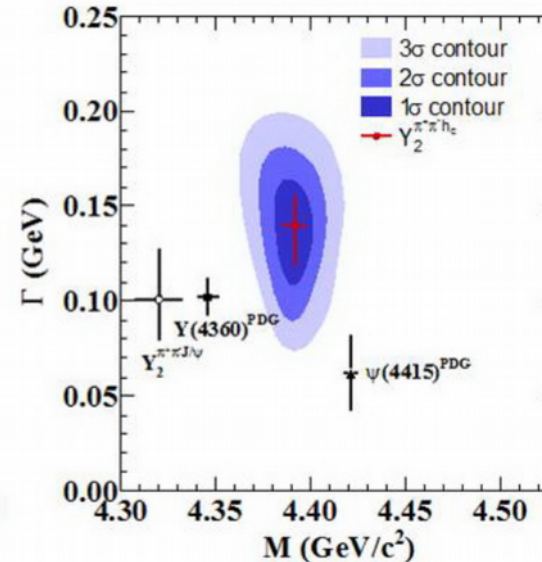
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<http://english.ihep.cas.cn/doc/1993.html>



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Misure di precisione alla soglia della Δ_c



Λ_c a BESIII

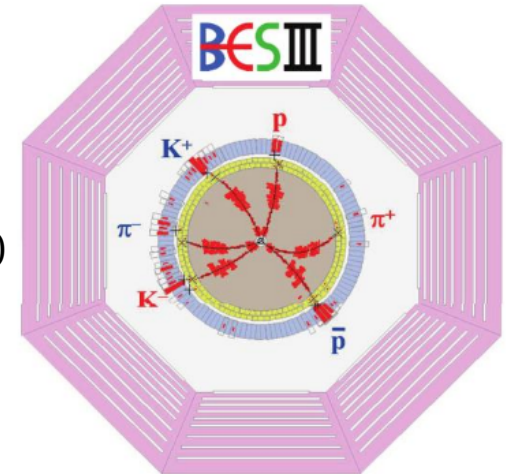
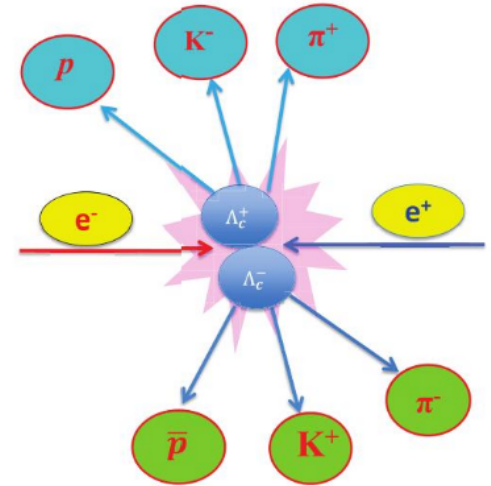
Il programma è iniziato nel 2013 con 4 serie di dati a energie nel centro di massa prossime a soglia (~ 500 /pb)

Opportunità concreta di competere con le B-factory

Produzione a soglia: cinematica chiusa
con un livello di fondo molto basso.

Publicati diversi articoli:

- $\Lambda_c \rightarrow \Lambda e \nu$ (PRL115, 221805 (2015))
- First Direct Measurement of Λ_c BF at threshold (PRL116 052001 (2016))
- $\Lambda_c \rightarrow pKK$ e $\Lambda_c \rightarrow p\pi\pi$ (PRL117 232002 (2016))
- $\Lambda_c \rightarrow nK_s^0\pi^+$ (PRL 118, 112001 (2017))
- $\Lambda_c \rightarrow \Lambda\mu\nu$ (Phys. Lett. B 767, 42 (2017))
- $\Lambda_c \rightarrow p\eta$ e $\Lambda_c \rightarrow p\pi^0$ (arXiv: 1702.05279)



Λ_c a BESIII

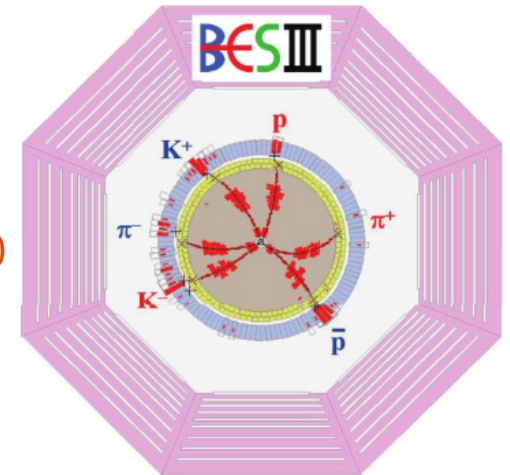
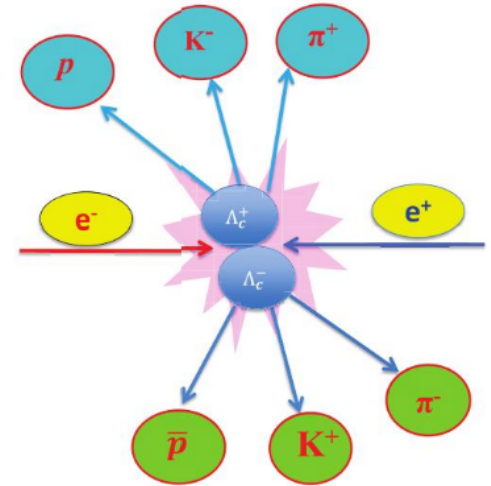
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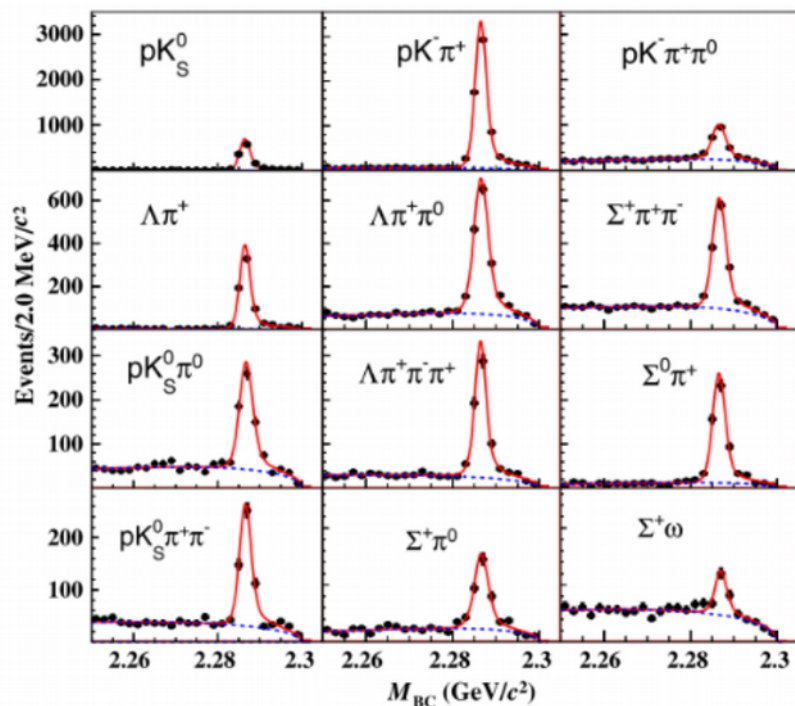
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Prima misura diretta dei rapporti di decadimento della Λ_c a soglia

PRL116 052001 (2016)

15400 eventi ricostruiti attraverso 12 modi di decadimento



Fit simultaneo per migliorare i singoli risultati

La precisione di $\Lambda_c \rightarrow pK\pi^+$ comparabile con quella di BELLE

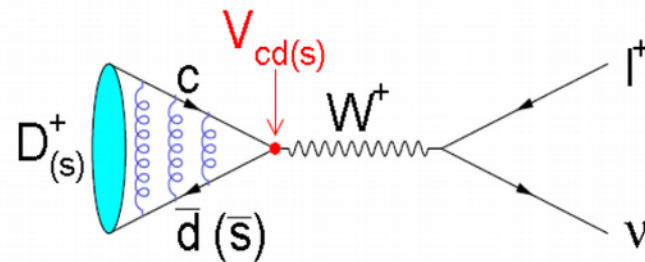
Mode	This work (%)	PDG (%)	BELLE \mathcal{B}
pK_S^0	$1.52 \pm 0.08 \pm 0.03$	1.15 ± 0.30	
$pK^- \pi^+$	$5.84 \pm 0.27 \pm 0.23$	5.0 ± 1.3	$6.84 \pm 0.24^{+0.21}_{-0.27}$
$pK_S^0 \pi^+ \pi^0$	$1.87 \pm 0.13 \pm 0.05$	1.65 ± 0.50	
$pK_S^0 \pi^+ \pi^-$	$1.53 \pm 0.11 \pm 0.09$	1.30 ± 0.35	
$pK^- \pi^+ \pi^0$	$4.53 \pm 0.23 \pm 0.30$	3.4 ± 1.0	
$\Lambda \pi^+$	$1.24 \pm 0.07 \pm 0.03$	1.07 ± 0.28	
$\Lambda \pi^+ \pi^0$	$7.01 \pm 0.37 \pm 0.19$	3.6 ± 1.3	
$\Lambda \pi^+ \pi^- \pi^+$	$3.81 \pm 0.24 \pm 0.18$	2.6 ± 0.7	
$\Sigma^0 \pi^+$	$1.27 \pm 0.08 \pm 0.03$	1.05 ± 0.28	
$\Sigma^+ \pi^0$	$1.18 \pm 0.10 \pm 0.03$	1.00 ± 0.34	
$\Sigma^+ \pi^+ \pi^-$	$4.25 \pm 0.24 \pm 0.20$	3.6 ± 1.0	
$\Sigma^+ \omega$	$1.56 \pm 0.20 \pm 0.07$	2.7 ± 1.0	

Precisione migliorata per 11 stati finali

La precisione per gli stati barionici ha finalmente raggiunto quella per gli stati mesonici

Pillole dagli altri ambiti di analisi

$$D_{(s)} \rightarrow l \nu$$

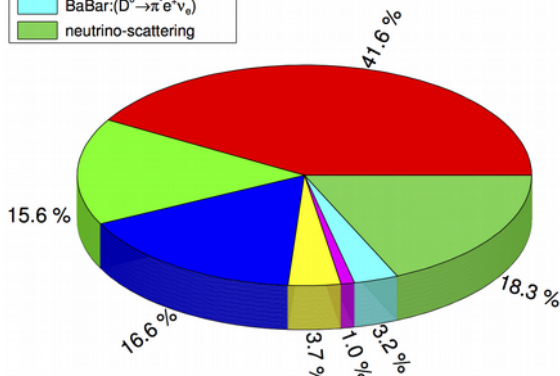
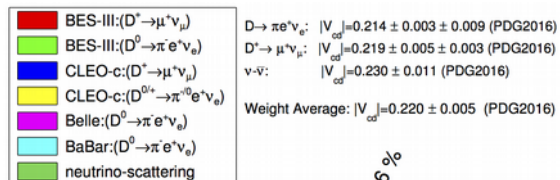


Decadimenti leptonici ambiente ideale per studiare la
mutua interazione fra forza forte e debole

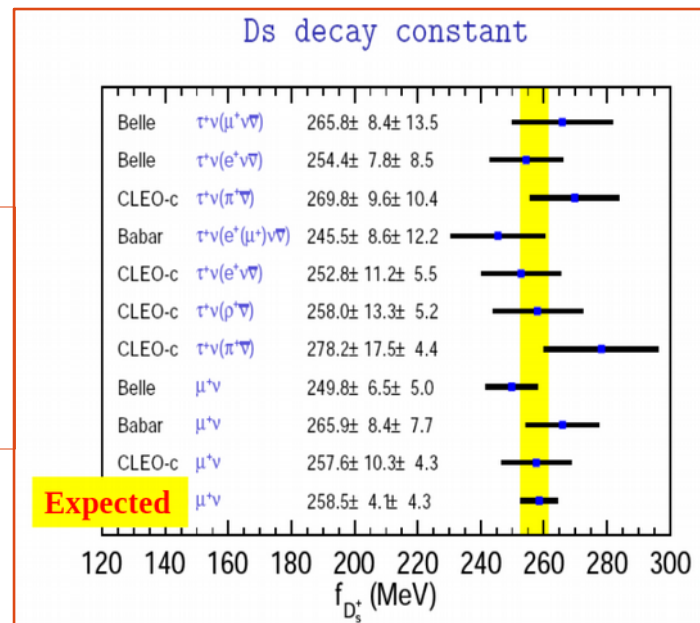
BESIII ha un ruolo fondamentale:

- per le misure dirette
- per rafforzare la conoscenza sui decadimenti del B

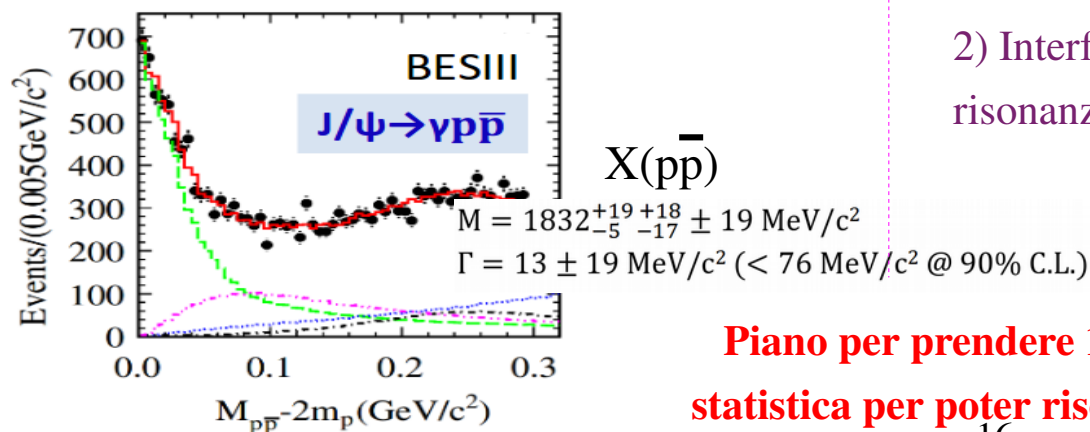
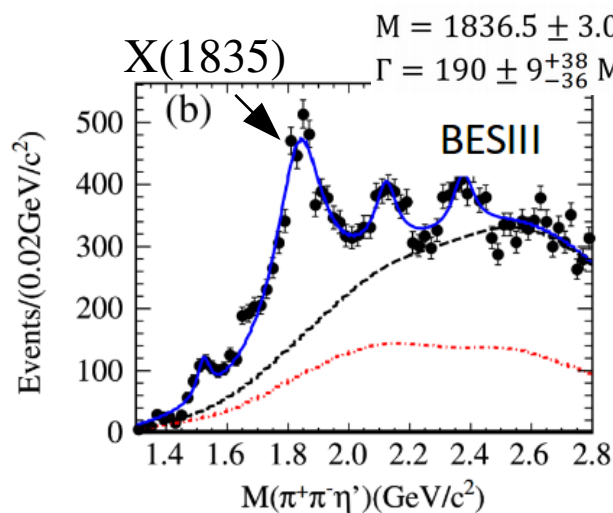
$$\Gamma(D_{(s)}^+ \rightarrow \ell^+ \nu_\ell) = \frac{G_F^2 f_{D_{(s)}^+}^2}{8\pi} |V_{cd(s)}|^2 m_\ell^2 m_{D_{(s)}^+} \left(1 - \frac{m_\ell^2}{m_{D_{(s)}^+}^2}\right)^2$$



Stato della misura +
previsioni con 3/fb
raccolti nel 2016



Studio della sezione d'urto di $J/\psi \rightarrow \gamma \eta' \pi^+ \pi^-$

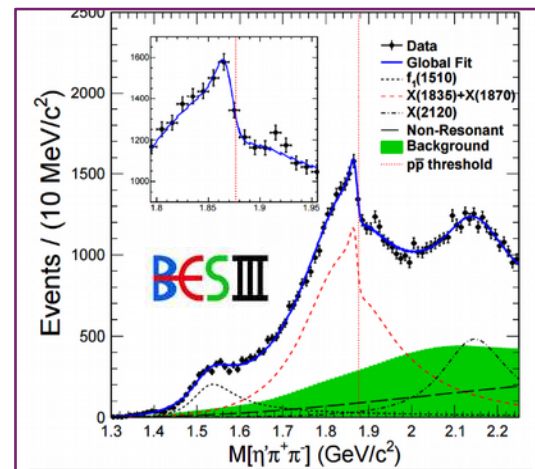
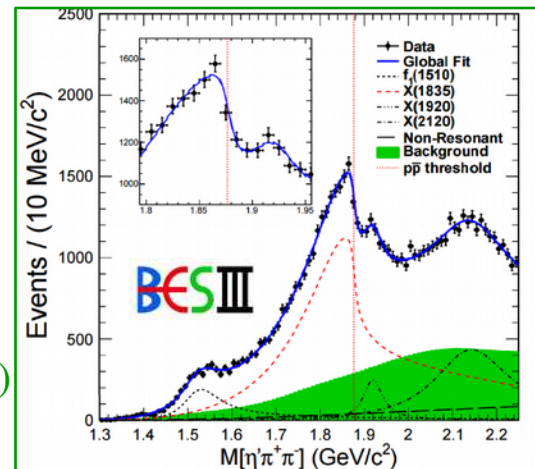


Per comprendere natura dei due stati, studio andamento sezione d'urto $J/\psi \rightarrow \gamma \eta' \pi^+ \pi^-$
 PRL 117, 042002 (2016)

Due soluzioni equivalenti

1) Flattè (apertura della soglia)

2) Interferenza coerente di due risonanze



Piano per prendere 10 volte l'attuale statistica per poter risolvere l'ambiguità

Sommario



Sommario

BESIII opera con successo dal 2009 grazie alle ottime prestazioni di BEPCII

Vasto programma copre differenti ambiti (Charmonio, esotici, mesoni e barioni charmati, spettroscopia)

τ -charm factory con una finestra unica sugli stati XYZ

Con le misure sul $D_{(s)}^{(*)}$ può fornire importantissimi contributi agli studi dei decadimenti del mesone B.

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BESIII ha in programma una serie di miglioramenti per l'acceleratore (arrivare alla Y(4660)), il tracciatore interno (progetto CGEM-IT, presentazione di Lia Lavezzi, qui ad IFAE) e un programma di fisica per rimanere attivo per i prossimi anni!

**G
R
A
Z
I
E**

**谢
谢**

Materiale Aggiuntivo

Potete chiaccherare ad IFAE con...



2017年春季第十八届北京谱仪实验物理与软件国际研讨会

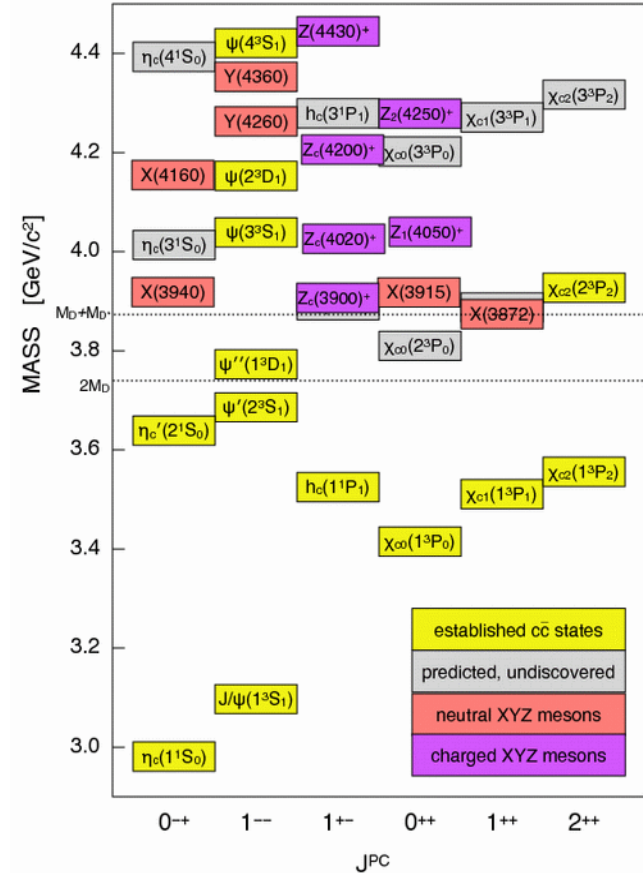
Jacopo Pellegrino

Lia Lavezzi

Giulio Mezzadri

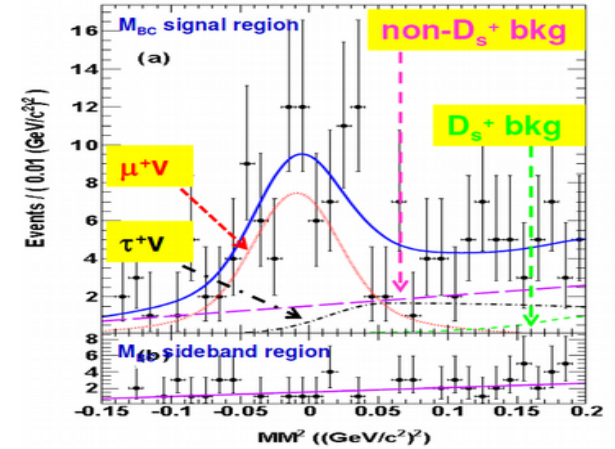
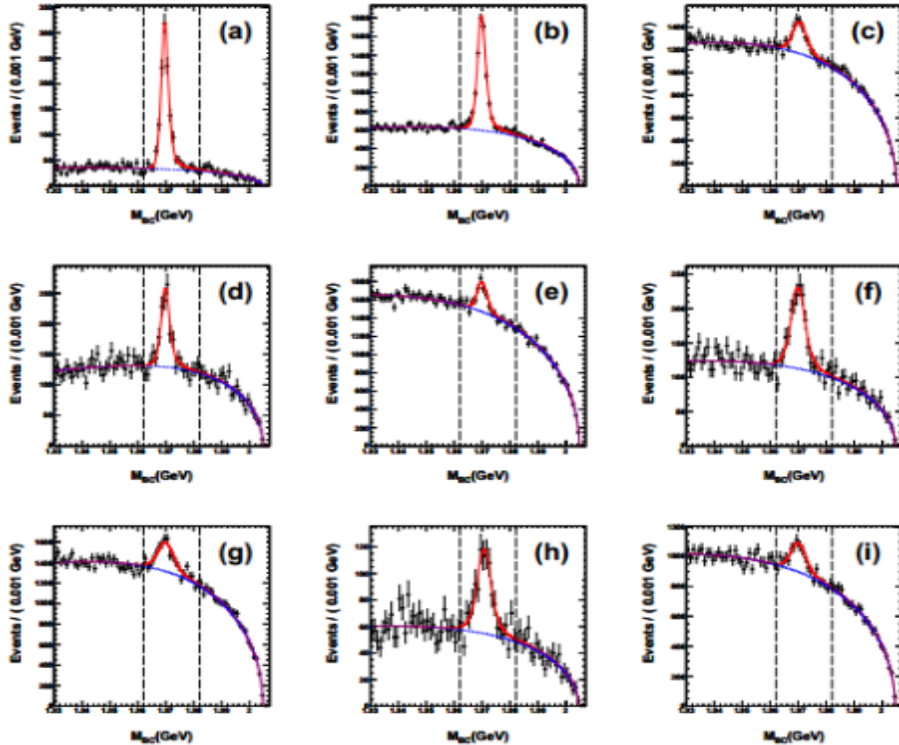
Classificazione stati XYZ

- Stati X:
 - Neutri con $J^{PC} \neq 1^{--}$
 - X(3872) (PRL 91, 262001 2003), X(3940) (PRL 98, 082001, 2007)
- Stati Y:
 - Neutri con $J^{PC} = 1^{--}$
 - Y(4260) (PRD 86, 051102, 2012) , Y(4360) (PRD 91,112007, 2015)
- Stati Z:
 - Carichi, tripletti isospin
 - Z(3900) (PRL 110, 252001, 2013), Z(4020) (PRL 111, 242001 (2013)), Z(4430) (PRL 100, 142001, 2008)



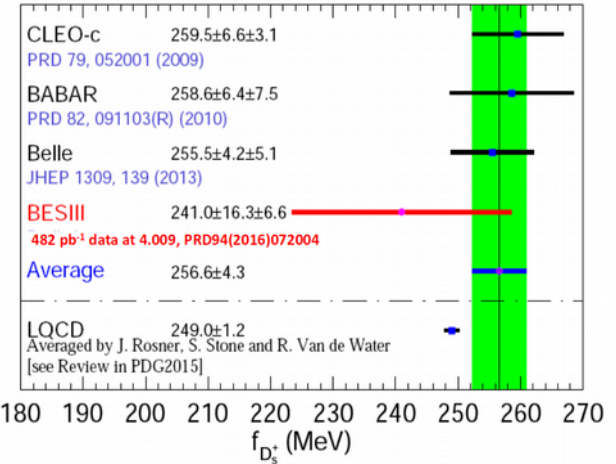
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Statistica di 482/pb @ 4.009 GeV

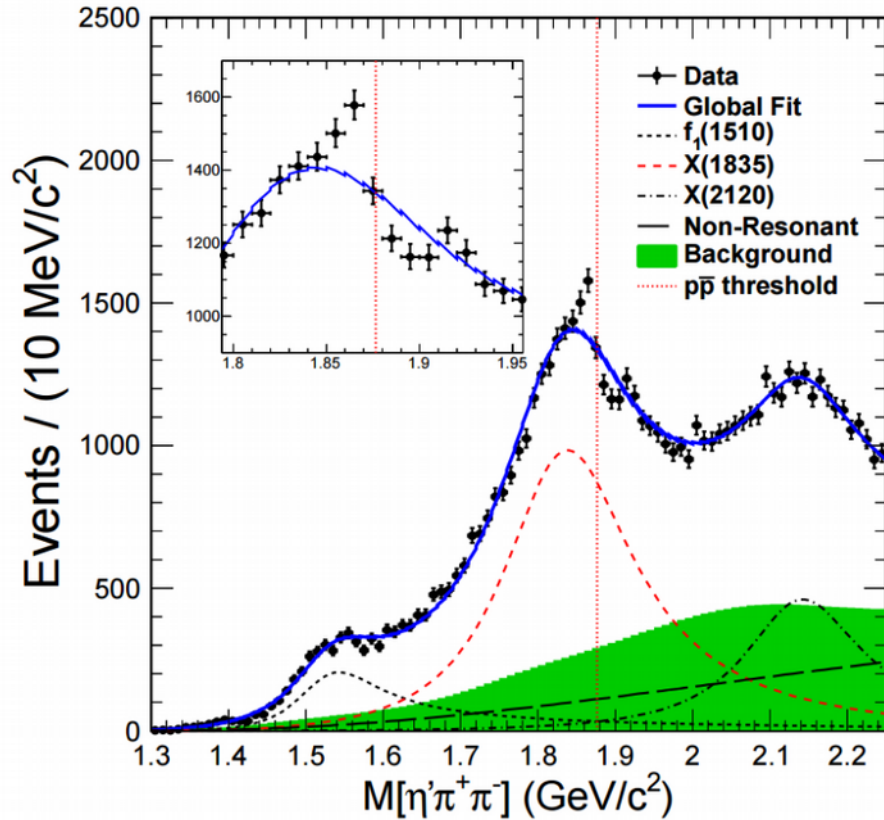


$$B[D_s^+ \rightarrow \mu^+\nu] = (0.495 \pm 0.067 \pm 0.026)\%$$

$$B[D_s^+ \rightarrow \tau^+\nu] = (4.83 \pm 0.65 \pm 0.26)\%$$



Studio della sezione d'urto di $J/\psi \rightarrow \gamma \eta' \pi^+ \pi^-$



- Fit simultaneo a due modi di decadimento di η'
- Una semplice Breit-Wigner non è sufficiente a descrivere l'andamento

Studio della sezione d'urto di $J/\psi \rightarrow \gamma\eta'\pi^+\pi^-$

Flatté formula

$$T = \frac{\sqrt{\rho_{out}}}{\mathcal{M}^2 - s - i \sum_k g_k^2 \rho_k}$$

$$\bullet \sum_k g_k^2 \rho_k \approx g_0^2 \left(\rho_0 + \frac{g_{p\bar{p}}^2}{g_0^2} \rho_{p\bar{p}} \right)$$

- $g_{p\bar{p}}^2/g_0^2$ is the ratio between the coupling strength to the $p\bar{p}$ channel and the summation of all other channels

Significance of $g_{p\bar{p}}^2/g_0^2$ being non-zero is larger than 7σ

The state around 1.85 GeV/c ²	
\mathcal{M} (MeV/c ²)	1638.0 ^{+121.9 +127.8} _{-121.9 -254.3}
g_0^2 ((GeV/c ²) ²)	93.7 ^{+35.4 +47.6} _{-35.4 -43.9}
$g_{p\bar{p}}^2/g_0^2$	2.31 ^{+0.37 +0.83} _{-0.37 -0.60}
M_{pole} (MeV/c ²) *	1909.5 ^{+15.9 +9.4} _{-15.9 -27.5}
Γ_{pole} (MeV/c ²) *	273.5 ^{+21.4 +6.1} _{-21.4 -64.0}
Branching Ratio	$(3.93 +0.38 +0.31-0.38 -0.84) \times 10^{-4}$

* The pole nearest to the $p\bar{p}$ mass threshold

Coherent sum of 2 BW

$$T = \frac{\sqrt{\rho_{out}}}{M_1^2 - s - iM_1\Gamma_1} + \frac{\beta \cdot e^{i\theta} \cdot \sqrt{\rho_{out}}}{M_2^2 - s - iM_2\Gamma_2}$$

X(1835) X(1870)

Significance of narrow X(1870) is larger than 7σ

X(1835)	
M (MeV/c ²)	1825.3 ^{+2.4 +17.3} _{-2.4 -2.4}
Γ (MeV/c ²)	245.2 ^{+14.2 +4.6} _{-12.6 -9.6}
B.R. (constructive interference)	$(3.01 +0.17 +0.26-0.17 -0.28) \times 10^{-4}$
B.R. (destructive interference)	$(3.72 +0.21 +0.18-0.21 -0.35) \times 10^{-4}$
X(1870)	
M (MeV/c ²)	1870.2 ^{+2.2 +2.3} _{-2.3 -0.7}
Γ (MeV/c ²)	13.0 ^{+7.1 +2.1} _{-5.5 -3.8}
B.R. (constructive interference)	$(2.03 +0.12 +0.43-0.12 -0.70) \times 10^{-7}$
B.R. (destructive interference)	$(1.57 +0.09 +0.49-0.09 -0.86) \times 10^{-5}$